Chapter 14
Direct Social Losses - Displaced Households Due to Loss of Housing Habitability and Short Term Shelter Needs

14.1 Introduction

Earthquakes can cause loss of function or habitability of buildings that contain housing units, resulting in approximately predictable numbers of displaced households. These households may need alternative short-term shelter, provided by family, friends, renting apartments or houses, or public shelters provided by relief organizations such as the Red Cross, Salvation Army, and others. For units where repair takes longer than a few weeks, long-term alternative housing can be accommodated by importing mobile homes, occupancy of vacant units, net emigration from the impacted area, and, eventually, by the repair or reconstruction of new public and private housing. While the number of people seeking short-term public shelter is of great concern to emergency response organizations, the longer-term impacts on the housing stock are of great concern to local governments, such as cities and counties. The methodology highlighting the Shelter component is shown in Flowchart 14.1.

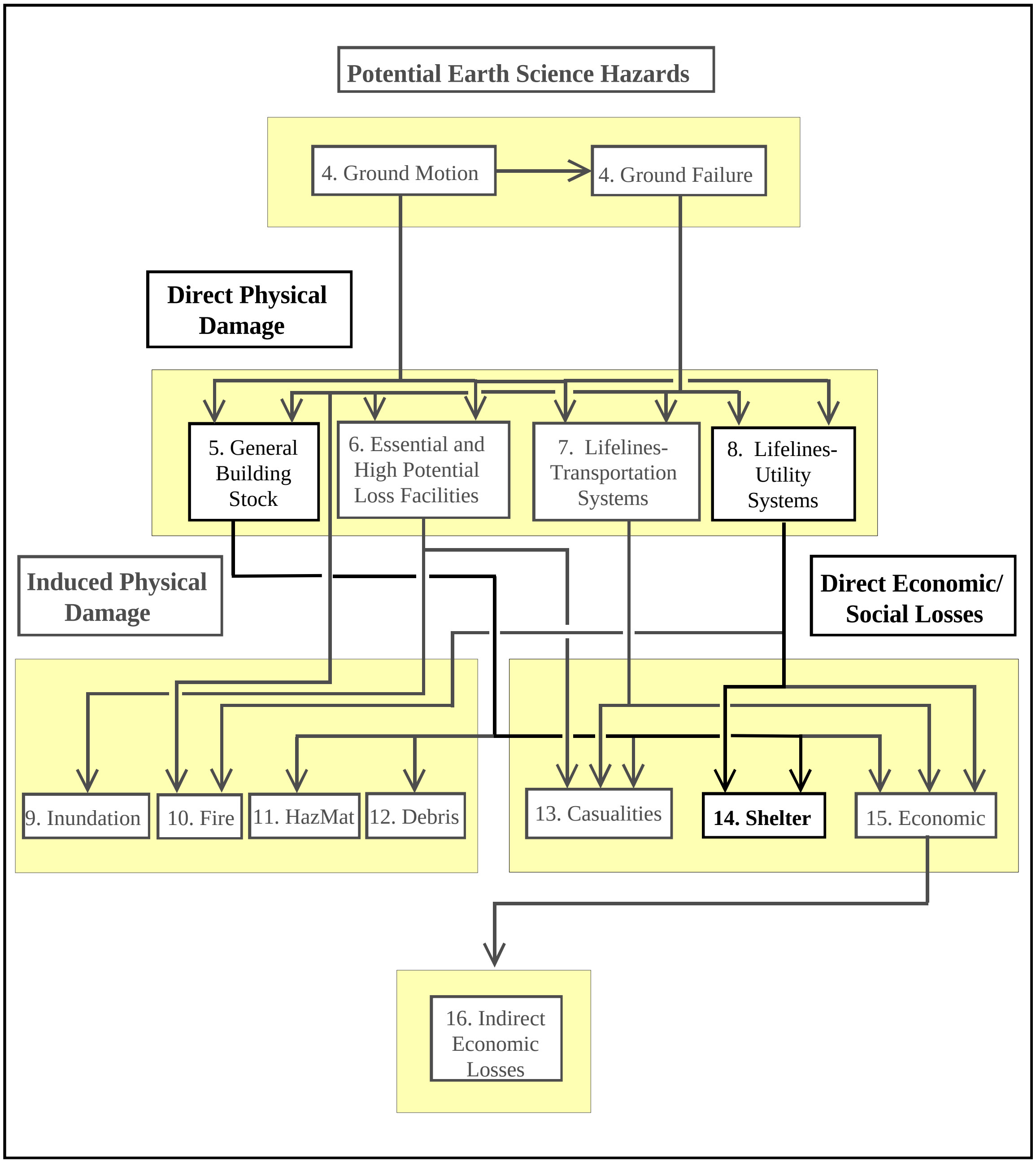
14.1.1 Scope

The shelter model provides two estimates:

- The number of displaced households (due to loss of habitability)
- The number of people requiring only short-term shelter

Loss of habitability is calculated directly from damage to the residential occupancy inventory, and from loss of water and power. The methodology for calculating short-term shelter requirements recognizes that only a portion of those displaced from their homes will seek public shelter, and some will seek shelter even though their residence may have no or insignificant damage.

Households may also be displaced as result of fire following earthquake, inundation (or the threat of inundation) due to dam failure, and by significant hazardous waste releases. This module does not specifically deal with these issues, but an approximate estimate of displacement due to fire or inundation can be obtained by multiplying the residential inventory in affected census tracts by the areas of fire damage or inundation derived from those modules. The hazardous materials module is confined to identifying locations of hazardous materials and no methodology for calculations of damage or loss is provided. If the particular characteristics of the study region give the user cause for concern about the possibility of housing loss from fire, dam failure, or hazardous materials, it would be advisable to initiate specific studies directed towards the problem, as a Level 3 study.



Flowchart 14.1: Direct Social Losses (Displaced Households) Relationship to other Components of the Earthquake Loss Estimation Methodology

14.2 Displaced Households - Form of Loss Estimate

The total number of uninhabitable dwelling units (#UNU) for each census tract of the study region is the output of this portion of the model. In addition, by applying an occupancy rate (households vs. dwelling units), the model converts the habitability data to the number of displaced households. The number of displaced households will be used in Section 14.3 to estimate the short-term shelter needs.

14.2.1 Input Requirements - Displaced Households

The following inputs are required to compute the number of uninhabitable dwelling units and the number of displaced households. The total number of units or households is provided in the default inventory based on census data (Section 3.6.2 of Chapter 3). The user can modify any values based on improved information.

- Total Number of Single-Family Dwelling Units (**#SFU)**
- Total Number of Multi-Family Dwelling Units (**#MFU**)
- Total Number of Households (**#HH**)
- Damage state probability for moderate structural damage in the single-family residential occupancy class (**%SFM**).
- Damage state probability for extensive structural damage state in the single-family residential occupancy class (**%SFE**).
- Damage state probability for complete structural damage state in the single-family residential occupancy class (**%SFC**).
- Damage state probability for moderate structural damage state in the multi- family residential occupancy class (**%MFM**).
- Damage state probability for extensive structural damage state in the multi- family residential occupancy class (**%MFE**).
- Damage state probability for complete structural damage state in the multi- family residential occupancy class (**%MFC**).

  [Note: The probabilities %SFM, %SFE, %SFC, %MFM, %MFE, and %MFC are provided by the Direct Physical Damage Module - Buildings (Chapter 5)].
- Probability that the residential units are without power and/or water (**%WAG**). The data is provided by the Utility System Module or as a user-specified input variable.

14.2.2 Description of Methodology

The estimated number of uninhabitable dwelling units is calculated from the following sources:

- Number of uninhabitable dwelling units due to structural damage (Equation 14-1)
- Number of uninhabitable dwelling units due to loss of utilities (units that would otherwise be habitable) (Equation 14-2)

The number of uninhabitable dwelling units due to structural damage is determined by combining a) the number of uninhabitable dwelling units due to actual structural damage, and b) the number of damaged units that are perceived to be uninhabitable by their occupants. Based on comparisons with previous work (Perkins, 1992; Perkins and Harrald, et. al., unpublished), the methodology considers all dwelling units located in buildings that are in the complete damage state to be uninhabitable. In addition, dwelling units that are in moderately and extensively damaged multi-family structures are also considered to be uninhabitable due to the fact that renters perceive some moderately damaged rental property as uninhabitable. On the other hand, those living in single-family homes are much more likely to tolerate damage and continue to live in their home. Therefore, the total number of uninhabitable units ($\#UNU_{SD}$) due to structural damage is calculated by the following relationship.

$$
\begin{aligned}
&\%SF = w_{SFM} \times \%SFM + w_{SFE} \times \%SFE + w_{SFC} \times \%SFC \\
&\%MF = w_{MFM} \times \%MFM + w_{MFE} \times \%MFE + w_{MFC} \times \%MFC \\
&\#UNU_{SD} = \#SFU \times \%SF + \#MFU \times \%MF
\end{aligned}
\tag{14-1}
$$

The values in Table 14.1 are provided as defaults. Due to the subjective nature of perceptions, users may want to change these values[1].

Table 14.1: Default Values for Damage State Probabilities

Weight Factor	Default Value
w_{SFM}	0.0
w_{SFE}	0.0
w_{SFC}	1.0
w_{MFM}	0.0
w_{MFE}	0.9
w_{MFC}	1.0

In addition to loss of habitable dwelling units due to structural damage, a substantial number of otherwise habitable units can be considered uninhabitable due to loss of water or power. This estimated number of otherwise habitable units that are without power and/or water is determined from inferred lifeline information based on Equation (14-2). In the absence of a lifeline utility analysis, the user can define the value of %WAG.

$$\#UNU_{UTL} = \%WAG \times \left[\#SFU(1 - \%SF) + \#MFU(1 - \%MF)\right] \tag{14-2}$$

[1]For guidance, research has shown a much clearer relationship between the red-, yellow- and green- tagging assigned by building inspectors and perceived habitability than between damage state and perceived habitability (Perkins and Harrald, et al., unpublished). Red- and yellow-tagged multi-family dwellings are considered uninhabitable, while only red-tagged single family homes are considered uninhabitable.

Depending on weather conditions, families living in these units may require only feeding and sources of potable water or may be forced to seek alternative shelter. A cold-weather event will also trigger a higher percentage of those affected by loss of power (heat) leaving their otherwise undamaged homes. Because no data exist on the impact of power losses on perceived habitability, this assessment has been left to the user. The user might pick a percentage of affected households (β) that would be considered displaced households based on, for example, the number of days that the temperature is below a specified level. Alternatively, the user might choose to run two scenarios, one in which 100% of those affected by a power outage needed to seek alternative shelter, and a second in which no one affected sought alternative shelter. The default values assumed for %WAG and β are zero.

By applying an occupancy rate (households vs. dwelling units), the habitability data is converted to the number of displaced households (#DH) using Equation 14-3.

$$\#\mathrm{DH} = \left(\#\mathrm{UNU}_{\mathrm{SD}} + b * \left(\#\mathrm{UNU}_{\mathrm{UTL}}\right)\right)\left(\frac{\#\mathrm{HH}}{\#\mathrm{SFU} + \#\mathrm{MFU}}\right) \tag{14-3}$$

14.3 Short Term Shelter Needs - Form of Loss Estimate

All households living in uninhabitable dwellings will seek alternative shelter. Many will stay with friends and relatives or in the family car. Some will stay in public shelters provided by the Red Cross or others, or rent motel or apartment lodging. This methodology estimates the number of displaced persons seeking public shelter. In addition, observations from past disasters show that approximately 80% of the pre-disaster homeless will seek public shelter. Finally, data from Northridge indicates that approximately one-third of those in public shelters came from residences with little or no structural damage. Depending on the degree to which infrastructure damage is incorporated into #DH, that number of displaced persons could be increased by up to 50% to account for "perceived" structural damage as well as lack of water and power.

14.3.1 Input Requirements - Short-Term Shelter Needs

The inputs required to estimate short-term housing needs are obtained from the displaced household calculations in Section 14.2 and from the default census data. As with the entire methodology, the census data can be modified with improved user information. The inputs listed below are the required census data inputs.

- Number of people in census tract (POP)
- Number of Households (#HH)
- Percentage of households whose income is under $10,000 ($HI_1$)
- Percentage of households whose income is $10,001 to $15,000 ($HI_2$)
- Percentage of households whose income is $15,001 to $25,000 ($HI_3$)
- Percentage of households whose income is $25,001 to $35,000 ($HI_4$)

- Percentage of households whose income is over \$35,000 (HI_5)
- Percentage of white households (HE_1)
- Percentage of black households (HE_2)
- Percentage of Hispanic households (HE_3)
- Percentage of Native American households (HE_4)
- Percentage of Asian households (HE_5)
- Percentage of households owned by householder (HO_1)
- Percentage of households rented by householder (HO_2)
- Percentage of population under 16 years old (HA_1)
- Percentage of population between 16 and 65 years old (HA_2)
- Percentage of population over 65 years old (HA_3)

14.3.2 Description of Methodology

Those seeking public shelter can be estimated from experience in past disasters, including both hurricanes and earthquakes. Those seeking shelter typically have very low incomes, for these families have fewer options. In addition, they tend to have young children or are over 65. Finally, even given similar incomes, Hispanic populations from Central America and Mexico tend to be more concerned about reoccupying buildings than other groups. This tendency appears to be because of the fear of collapsed buildings instilled from past disastrous Latin American earthquakes.

The number of people who require short-term housing can be calculated using the following relationship.

$$\#\mathrm{STP} = \sum_{i=1}^{5}\sum_{j=1}^{5}\sum_{k=1}^{2}\sum_{l=1}^{3}\left(a_{\mathrm{ijkl}} * \left(\frac{\#\mathrm{DH} * \mathrm{POP}}{\#\mathrm{HH}}\right) * \mathrm{HI}_i * \mathrm{HE}_j * \mathrm{HO}_k * \mathrm{HA}_l\right) \tag{14-4}$$

where

#STP	- Number of people requiring short term housing
a_{ijkl}	- is a constant defined by Equation 14-5
HI_i	- Percentage of population in the i^{th} income class
HE_j	- Percentage of population in the j^{th} ethnic class
HO_k	- Percentage of population in the k^{th} ownership class
HA_l	- Percentage of population in the l^{th} age class
POP	- Population in census tract

The value of the a_{ijkl} constant can be calculated using a combination of shelter category "weights" (Table 14.2) (which sum to 1.00) and assigning a relative modification factor (Table 14.3) for each subdivision of each category. In the methodology, default values for the variables for ownership and age are zero.

$$a_{\mathrm{ijkl}} = (\mathrm{IW} * \mathrm{IM}_i) + (\mathrm{EW} * \mathrm{EM}_j) + (\mathrm{OW} * \mathrm{OM}_k) + (\mathrm{AW} * \mathrm{AM}_l). \tag{14-5}$$

Table 14.2: Shelter Category Weights

Class	Description	Default
IW	Income Weighting Factor	0.73
EW	Ethnic Weighting Factor	0.27
OW	Ownership Weighting Factor	0.00
AW	Age Weighting Factor	0.00

Table 14.3: Shelter Relative Modification Factors

Class	Description	Default
Income		
IM_1	Household Income < $10000	0.62
IM_2	$10000 < Household Income < $15000	0.42
IM_3	$15000 < Household Income < $25000	0.29
IM_4	$25000 < Household Income < $35000	0.22
IM_5	$35000 < Household Income	0.13
Ethnic		
EM_1	White	0.24
EM_2	Black	0.48
EM_3	Hispanic	0.47
EM_4	Asian	0.26
EM_5	Native American	0.26
Ownership		
OM_1	Own Dwelling Unit	0.40
OM_2	Rent Dwelling Unit	0.40
Age		
AM_1	Population Under 16 Years Old	0.40
AM_2	Population Between 16 and 65 Years Old	0.40
AM_3	Population Over 65 Years Old	0.40

Within each of these categories, the default relative modification factors given in Table 14.3 can be used to calculate a_{ijkl} values (i.e., estimate the percentage of each category that will seek shelter) (with an average value for each category being 0.33 to 0.45). These constants were originally developed by George Washington University under contract with the Red Cross and are based on "expert" opinion (Harrald, Fouladi, and Al-Hajj, 1992). Recently collected data from over 200 victims of the Northridge earthquake disaster were analyzed and used in finalizing these constants (Harrald, et. al., 1994). The modification factors provided in Table 14.3 are the mean of the George Washington University modification factors described in these two reports. Data for Native Americans are extremely scarce. Some information from Alaskan disasters indicates that the factor for those seeking shelter is similar for whites and Asians.

14.3.3 User-defined Changes to Weight and Modification Factors

In the methodology, weights can be added which account for age and ownership. As noted in Section 14.3.1, the required population distribution data are available. Remember that the weights must sum to 1.0. Young families tended to seek shelter in a larger proportion than other age groups in Northridge, in part because of lower per capita income. This result is consistent with data from hurricanes. In hurricanes, and Northridge, the elderly populations were also more likely to seek public shelter than average. Use special care if you want to add ownership to ensure that you are not double counting because the multi-family versus single-family issue has already been taken into account when estimating habitability (moderately damaged multi-family units are considered uninhabitable while moderately damaged single family units are considered habitable).

Most recent earthquake disasters and hurricanes have occurred in warm weather areas. A major non-shelter location was the family car and tents in the family's backyard. Should an earthquake occur in a colder climate, more people would probably find these alternate shelters unacceptable. In the methodology, the user is able to adjust the factors specifying the percentage of those displaced that seek public shelter (i.e. the shelter relative modification factors in Table 14.3). When making modifications for weather, be careful not to double count. The adjustment for this module should only take into account the larger percentage of those displaced that will seek public shelter (versus the family car or camping in one's backyard.)

14.3.4 Guidance for Estimates Using Advanced Data and Models

The recent Loma Prieta and Northridge earthquakes in California have not been catastrophic events. Although many people have been displaced in these recent earthquake disasters, the size of the area or the spottiness of the damage have left people with more than minimal incomes the options of alternate shelters.

As noted above, Hispanic populations from areas of Central America and Mexico tended to be more concerned about reoccupying buildings with insignificant or minor damage than other groups because of the fear of collapsed buildings instilled from past disastrous earthquakes in Latin America. Such tendencies will probably expand to all ethnic groups should a large number of casualties occur.

14.4 Guidance for Estimating Long-Term Housing Recovery

Although not calculated by the methodology, the damage to residential units (calculated in the general building stock module) can be combined with relationships between damage and restoration times (in the functional loss module) to estimate the need for longer-term replacement housing. Longer-term needs are accommodated by importing mobile homes, reductions in the vacancy rates, net emigration from an area, and eventual repair or reconstruction of the housing units. Because replacement of permanent housing is subject to normal market and financial forces, low-income housing is the last type of housing to be replaced.

Based on experience in Loma Prieta (Perkins, 1992) and preliminary Northridge analyses (Perkins and Harrald, et. al., unpublished) housing recovery times span a wide range, and are typically far longer than might be estimated from typical planning rules of thumb, and longer than most commercial, industrial and institutional recovery. Housing recovery tends to be very dependent on settlement of insurance claims, federal disaster relief, the effectiveness of the generally smaller contractors who do much residential work, and the financial viability of the home or apartment owner, together with actions taken by state and local governments to expedite the process, and public support of reconstruction (such as the potential desire for historic preservation). The median recovery time figures for residential occupancies shown in Table 15.11 reflect these issues, but there will tend to be very wide variation about the mean. In particular, recovery times for non-wood frame multi-family housing, especially low-income single room occupancy buildings, ought to be measured in years.

14.5 References

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